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14. ABSTRACT

Traumatic combat injuries differ from those encountered in the civilian setting in terms of epidemiology, mechanism of wounding, pathophysiological trajectory following injury, and outcome. Except for a few notable exceptions, data sources for combat injuries have historically been inadequate.
Although the pathophysiologic process of dying is the same, i.e., dominated by exsanguination and central nervous system injury, in both the civilian and military arenas, combat trauma has unique considerations with regard to acute resuscitation, including (1) the high energy and high lethality of wounding agents; (2) multiple etiology of wounding; (3) preponderance of penetrating injury; (3) persistence of threat in tactical settings; (4) austere, resource-constrained environment; and (5) delayed access to definitive care. Recognition of these differences can help bring focus to resuscitation research for combat settings and can serve to foster greater civilian-military collaboration in both basic and transitional research.

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CASUALTY EVACUATION DELAY & OUTCOMES *Table of Contents*

Tab 1   Report on Injuries in General

- Anatomic Pathophysiology of Death Following Injury
- A Profile of Combat Trauma
- Rules of Thumb Results

Tab 2   Report on Injuries by Body Area – MTOS Analyses & Findings

- Abdomen
- Chest
- Massive Torso Trauma
- Head
- Limbs
- Neck
- Maxillofacial
- Burns
- Blast

Tab 3   Power Point Presentation

Tab 4   Report of Combat Trauma Registry

- Combat Trauma Registry Database
- Combat Trauma Registry Data Dictionary
- IECC Data Elements

Tab 5   Patient Condition Codes

Tab 6   Bibliography

Tab 7   Appendices

- Attachment I to Task Statement 4-99B
- Members of Review Panel
- Goals & Process Review Panel

Tab 8   CD ROM
- Text
- PowerPoint Presentation

I. Executive Summary

Introduction

The overarching theme of this project was to improve the knowledge of the consequences of delay in therapy on wounded individuals. The contractor was charged with studying the effect of delay on evacuation on outcome of combat casualties.

Such knowledge could be used to improve the basis for tactical decision making in care of combatants.   To this end a number of investigative directions were established.

Methodology

An extensive literature search was performed on combat injury data. The findings are summarized throughout this report. The main sources were the WDMET database and datasets from smaller engagements since the Vietnam War era. As a pre-eminent authority on combat data, Col. Ronald Bellamy MC USA (Ret) was extensively consulted and included in the preparation of this report. He helped to develop the archival resources based on the WDMET database and explore the limitations and strengths of many of the analyses that he and others had performed.

In addition, after-action reports were reviewed from prior conflicts particularly the Second Auxiliary Surgical Report from WWII. Others include:
- The study on the Physiological Effect of Wounds, performed by the Board for the Study of Severely Wounded, Office of the Surgeon General, Department of the Army, Washington, D.C.
- Medical Report: Operation Corporate [Land Forces Falkland Islands]
- Operation Just Cause
- Panama Casualty Data analysis, Office of the Surgeon General, Walter Reed Army Medical Center.
- Final Casualty Data Assessment Team Operation Desert Storm.

Data and many insights were obtained from many British military experts including Colonel Peter Roberts, Consultant, Advisor in surgery to the Director General of the Army Medical Directorate (U.K.) and from Giora Martonovitz, Surgeon General, Israeli Defence Force. Further data and information were obtained from the International Committee of the Red Cross surgeons who had treated patients in Pakistan from Afghanistan and in Kenya from Somalia, from Australian surgeons who treated patients in East Timor, from South African physicians involved in the mechanized land campaigns in Botswana, and from British medics and surgeons who treated

patients in Kosovo and Sierra Leone. The data and insights from this review of literature are integral to the discussion of injuries in the next several sections, and to the reviews that took place with US Military Medical Experts.

The contractor used two large civilian databases, called MTOS (approximately 178,000 patients) and PTSF (approximately 170,000 patients) and performed analyses on a number of samples selected to study the pathophysiological sequelae of various types and combinations of injuries. The findings of these analyses were discussed by a panel of military and civilian experts, presented at a number of meetings for critical comment and subject to detailed discussions with key Special Forces leadership personnel. This process has resulted in a crystallization of prognostic issues regarding early combat casualty care and has in no small part prompted a resurgence of interest in early combat management of hemorrhage and in combat fluid resuscitation. PowerPoint presentations of the findings, rules of thumb and guidelines were prepared and are part of this report.

The WDMET database from Vietnam is now thirty years old. Since then there has been no attempt to aggregate data on contemporary combat injured. Such an aggregate database is an absolute prerequisite for powering statistical analyses from which meaningful conclusions can be drawn.

The International Combat Trauma database was established as part of this contract. The purpose of this initiative was to refine the means whereby small data sets of injuries could be consolidated in a uniform manner so that analyses on sufficient number of patients could be performed from which to draw meaningful and statistically valid conclusions.

Results

The results provide a contemporary compendium of knowledge of combat injury and outcome. They identify patterns of injury and physiologic states that determine time-sensitive risk of adverse outcomes.

The analyses performed as part of this contract provided the basis for broad ranging discussions on the need for further investment in combat casualty care and resuscitation research. They have provided substantial insights into the early management of combat casualties in resource-constrained environments and have provided a substrate on which to revise such management guidelines. Data from these analyses have been presented at at least a dozen national and international meetings. A number of publications will ensue. The process of improving combat trauma care is iterative. This project made a contribution to that process.

There are a remarkably small proportion of patient diagnoses and states in which time has an effect on outcome. This is because the vast majority of patients will either inevitably die or outcome will not be substantially altered by definitive therapy within hours and in some cases days. Those, in whom time is important, include patients with respiratory distress that cannot be relieved, and hemorrhage which cannot be controlled. The patterns of injury and physiological states that signify this time dependence are discussed in detail.

The International Combat Trauma Registry has been transitioned with funds from the US Army MRMC and with the support from the Center for AMEDD Strategic Studies at Fort Sam Houston. It is in the process of being web-enabled. It has been deployed with the forward surgical teams in Afghanistan.

USAMRMC continues to provide funding for the database, which is permitting the WDMET to be reformatted to enable comparative analyses. Patient data continues to be acquired for this important on-going effort. It is anticipated that by 2003, at least 12,000 patients from a variety of sources, including the WDMET, will be a part of this database providing a unique and valuable resource for studying the epidemiology and outcome of combat injuries and for developing hypothesis-driven research projects of relevance to injured combatants.

Patient Condition Codes

Patient Condition codes (PC's), developed by the US Army and used by the US Navy and Marines, are general descriptions of injuries and illnesses that may be encountered in military settings. Many of the descriptions have poor granularity and cannot be consistently applied. The Principal Investigator has attempted to provide some rigor to the Patient Condition Codes applying definitions and coding them in the available anatomical taxonomies. In addition, physiological data have been ascribed to each injury PC. Using data from MTOS, probability of survival was calculated and the effect of time delay on therapy estimated, together with the resource requirements. This exercise which was funded by a small contract from the Marine Commandant's Warfighter's Lab is provided to SOCOM under Tab 5. Please note that these are civilian data and should be advisedly applied to military settings.

Finally a word of caution. As any student of combat injury will rapidly discover, there is no consistency in the definitions used in the various databases and studies. Thus some statistics may seem at variance. This is

usually as a result of shifting denominators between different sources of data. The Principal Investigator has taken pains to try and eliminate any such inconsistencies. Some may, however, persist which may be resolvable by discussions with the Principal Investigator or the repeat analysis of primary data where available.

Summary

This contract provided the resources for some important new analyses which have caused a greater understanding of the pathophysiological sequelae of injury and as to how this information could be integrated into combat casualty care. It has served to help promote a reinvigoration of research into combat casualty care and resuscitation and helped to bring focus from those agencies responsible for such research. It has provided the resources for the development of the International Combat Trauma Registry which is now organic to the US Army with tri-service use in current conflicts. SOCOM will receive copies of the trauma registry as data are added and anatomical coding is completed and of the publications that will ensue from this research.

II. Summary of Achievements relative to stated Specific Aims

Introduction

The project will combine empirical information with expert operational and military and civilian medical opinion to fashion a robust and reliable methodological infrastructure for planning for combat casualty care in a variety of scenarios, but with a special emphasis on estimating the effect of delayed evacuation on injury outcome and means to mitigating such effects.

Since some of the Specific Aims were somewhat modified as a result of the first presentation of data at the Panel Review of December 14, 2002, and at the BISC Meeting, specific statements as to what was done relative to the originally conceived Specific Aims are warranted.

Objectives

1. Conduct research into the impact of delays in evacuation on casualty outcome of the injuries and clinical indications shown in Attachment 1 to Task Statement 4-99B. Assume that Care under Fire and Tactical Field Care are provided according to current guidelines. Add an additional injuries and/or clinical indicators deemed appropriate.

   Completed as stated.

2. Prepare a chart in the format supplied with expected survival at 1, 4, 12 and 24 hours.

   Completed as requested.

Specific Aims

1. Develop a database of contemporary combat injuries and outcomes, including those dead at the scene.

   This component of the project was initiated and continues to thrive with funding support from USAMRMC and technical support from USA AMEDD Center and School. It has the interest and continued participation of the British military. It has the enthusiastic interest and ongoing desire to participate from the Office of the Surgeon General of the Israeli Defence Force. The Access database has been converted to wed-enabled SQL. A team from AMEDD Center and School is field testing the database in Germany as of mid-July 2002.

2. Use case-matched samples from civilian databases to obtain timelines between injury and needed treatment or adverse outcome.

   Case-matched samples of the injuries listed in Attachment 1 to Task Statement 4-99B were analyzed in detail, reviewed and formed the basis of the findings of this research.

3. Convene panels nominated by end-users to develop charts specific to the requirements in Attachment 1 to Task Statement 5-99B for specific injuries and expected evacuation procedures. The result will be to provide the Special Operations community with a methodology for this assessment and risk avoidance for combat casualty care.

   A panel of end-users was convened in December 2001. Thereafter, detailed, ongoing reviews took place with Special Forces leadership figures to fine tune the findings and results.

4. Estimate the impact of the following on outcome (from Task Statement)
   - Time delay to definitive care
   - Limited field care availability
   - Remote diagnostics and other technologies
   - New and improved therapeutics

   Statements regarding these are provided.

III. Methodological Overview for Injury Analyses

Civilian Data Analyses

Analyses were performed on patient samples from two large civilian databases. The analyses were designed to provide greater insight into the relationship between nature and severity of injury and shock states following injury and the pathophysiological sequelae and outcome.

A. Major Trauma Outcome Study (MTOS) Analyses.

The MTOS is approximately 178,000 patients treated in 140 hospitals in the US and Canada throughout the late 1980's. Approximately 20% of the patients have penetrating injuries. Over half of these are gunshot wounds. Seventy-three (73%) percent of the patients are between 15 and 55 years of age. The mortality in this dataset is 9% attesting to general severity of the injured patient population. The mortality in the patients with gunshot wounds was 20.9%. (Mortality in combat injuries is 20-25%.)

A highly select subset of these patients was chosen for the initial analyses. These data were meticulously collected at four of the leading trauma centers in the United States and were scrupulously checked for accuracy and completeness. Study patients analyzed were 7931 males, aged 18 to 45. All were primary admissions, no transfers, and no co-morbid conditions.

Severity Indices

Both physiologic and anatomic indices are required to effectively characterize injury severity. The Revised Trauma Score (RTS), a physiologic index of injury severity, is computed from coded value (0-4) of the Glasgow Coma Scale (GCS), systolic blood pressure (SBP) and respiratory rate (RR), obtained in the field and on emergency department admission. These values are multiplied by weights determined by logistic regression of a baseline data set

$$RTS = 0.9368 \ (GCS) + 0.7326 \ (SBP) + 0.2908 \ (RR).$$

The RTS takes on values between 0 and 7.8408. Higher values are associated with improved prognoses. The RTS has been shown to more reliably predict outcome than its predecessor, the Trauma Score. The unweighted sum of coded RTS variables has been proposed by the American College of Surgeons for field triage of injured patients.

Physiological Data Codes				
Code	Pulse	Resp Rate	SBP	GCS
4	61-120	10-29	> 89	13-15
3	> 120	> 29	76-89	9-12
2	41-60	6-9	50-75	6-8
1	1-40	1-5	1-49	4-5
0	0	0	0	3

The Injury Severity Score is an index of anatomic injury severity that takes values from 1 to 75. Higher scores generally indicate more severe injuries. The ISS is based on the Abbreviated Injury Scale (AIS). The AIS is a list of several hundred injuries, each with an assigned severity score that can range from 1 (minor injuries) to 6 (injuries that are nearly always fatal). To compute the ISS, a patient's injuries are sorted into six body regions: head and neck, face, chest, abdominal and pelvic contents, extremities and pelvic girdle, and external. If the patient has any AIS 6 injury, the ISS is 75 by definition. Otherwise, the highest AIS severity score in each of the six body regions is identified, and the squares of the largest three are added to obtain the ISS.

Anatomic Codes – AIS	
1	Insignificant
2	Minor
3	Moderate
4	Major
5	Severe
6	Lethal

The principal investigator developed the MTOS database, the Trauma Score and the TRISS methodology for combining the Trauma Score, ISS, Age and Mechanism of Injury to predict outcome. All patients in MTOS and PTSF are coded in AIS and other anatomic coding formats.

Since the patients reviewed have been selected to mimic combat injured, the age bounds of the data presented are males 18 to 45. There is no age effect within these bounds.

Co-morbid conditions rarely exist in this age group. Such patients have been excluded from these analyses.

Patient Sampling

The following groups of male patients (18-45) were extracted from the MTOS database:

- Gunshot wound to the Abdomen
- Gunshot wound of Chest
- Gunshot wound of Head
- Gunshot wound to Extremity
- Gunshot wound of Neck
- Gunshot wound Maxillofacial
- Traumatic Amputation
- Closed Head Injury
- Blunt Maxillofacial Injury
- Burns
- Blast Injury
- Crush Injury
- Massive Torso Injury
- MTOS does not include burns or blast injury

In the MTOS Results section (Section V) of this report analyses are presented by body area groupings as follows:

- Abdomen
- Chest
- Neck
- Limbs
- Maxillofacial
- Burns
- Blast

In each section a review of the available military data is followed by a discussion of the civilian data, based on the findings from MTOS and PTSF, if applicable. Details of the PTSF study design and results immediately follow.

The MTOS study design is presented as follows:

1. Anatomical data. The levels of anatomical severity of injury in each body area were usually divided into relatively minor, i.e., AIS 1 and 2, and more severe (AIS 3 and above).

   In most cases the analyses showed minimal mortality in AIS 1 and 2.

   AIS 3 and above were tabulated and converted into histograms to show the added effect of increasing severity of injury in other body areas. Thus, the effect of AIS 1, 2, 3, 4 and 5 in other body areas on an abdominal AIS 3 injury was shown and then the effect on AIS 1, 2, 3, 4, 5 other body areas on an abdominal AIS 4 injury were shown. These data vividly displayed the differences in impact of multiple

injuries on various degrees in severity of injuries in certain body areas. For instance, severe head and chest injuries so dominate the risk of death, that the influence of injuries in other body areas have little effect. However, there is clear effect of increasing severity of injury in other body areas on limb injuries, medium severity abdominal injuries and maxillofacial injury. It is the first time that such interdependencies have been demonstrated.

2. Physiological data. The physiological data for each body area was analyzed to determine the change mortality related to degradation of physiological status and over time to death. The physiological variables analyzed were:
   - Systolic blood pressure
   - Pulse
   - Respiratory rate, and where appropriate
   - Glasgow Coma Score.

   Tables and charts were generated to display the impact of varying degrees of abnormality for multiple sets of variables. These tables frequently have gaps because of the paucity of numbers of certain physiological combinations required of a given data cell. Systolic blood pressure was replaced by pulse in most cases because of the unavailability of blood pressure data at the point of wounding care for combat casualties. In some cases physiologic data were only available for ER admission and not for prehospital care.

B. The Pennsylvania Trauma Systems Foundation (PTSF) Analyses

This part of the study was specifically designed to look at the effect of delay in definitive surgery on outcome of patients in shock after injury. Abdominal surgery is one of the surgical interventions most often required if hemorrhage has not been controlled by other means.

Information from the Pennsylvania Trauma Systems Foundation (PTSF) Trauma Registry was used for the study. The PTSF Trauma Registry is a population-based database from all the Level I and Level II trauma centers in the State of Pennsylvania.   It has approximately 170,000 patients in it. It contains information on all injured patients cared for at Pennsylvania trauma centers who die, are transferred to other trauma centers, or have a hospital stay of more than two days; patients with isolated hip fractures are excluded. The registry began enrolling patients in October 1986. It continues to enroll. The data set is very similar to and is based on MTOS.

The PTSF Trauma Registry includes the following information used for this study: the time of injury, the time the ambulance was dispatched, the time the patient arrived at the hospital's ED, the patient's systolic blood pressure (SBP) on arrival in the ED, the patient's diagnoses, pre-existing conditions, the time the patient left the ED, the time the patient arrived in the operation room (OR), the operative procedures done, and the patient's outcome (lived or died). It did not include information about fluid given to the patient or the systolic blood pressure on departure from the ED or arrival in the OR.

This study was restricted to patient who were brought directly to the trauma centers from the injury scene prior to July of 1999, were not transferred from the ED to another hospital, and did not have confounding burn injuries (N=166,768). The cohort for this study was further restricted to patients who had no documented confounding preexisting conditions (N=130,302). From this group of injured patients without confounding conditions who were brought directly to a trauma center, patients who met the following criteria were identified:

The patient's systolic blood pressure was greater than 0 mmHg and less than or equal to 90 mmHg on arrival in the ED.

The patient either died in the ED or was transferred from the ED to the OR for a laparotomy.

The patient had an abdominal vascular, solid organ, or wall injuries with an Abbreviated Injury Scale score (AIS) in the range of 3-6.

The patient had no injuries with AIS > 2 in any other body region except for a lacerated diaphragm (440604.3) or an open, displaced, or comminuted pelvic fracture (852604.3).

Either the time of injury or ambulance dispatch and the time of arrival to the Ed and the time of departure from the ED or death in the ED or arrival to the OR were recorded.

For each patient, the SBP on arrival to the Ed and the outcome were recorded and the following were calculated:

The elapsed time to the ED (prehospital time) was calculated from either the dispatch time, when known, or the injury time (in that order of preference) and the time of arrival to the ED. The time of dispatch was preferred, for consistency, because the registry permitted registrars to enter the time of dispatch as an undeclared default for the time of injury when the time of injury was otherwise unknown.

The elapsed time in the ED was calculated from the time of arrival to the ED and the time of arrival in the OR or the time of departure from the ED (in that order of preference).

Short times to care could either decrease mortality rates or imply that patients were at high risk of death and that long times to care could either increase mortality rates or imply that patients had a low risk of death. Therefore, times to care might not predict outcome monotonically. Because of the potential fluctuations in the direction of the relationship between time and outcome, the data were analyzed using interval risk ratios rather than regression formulas.

A risk ratio (RR) of death associated with an attribute is the ratio of two percentages: the percentage of individuals with the attribute among those who dies compared to the percentage of individuals with the attribute among those who lived (RR = % with attribute among deaths/ % with attribute among survivors). Attributes with risk ratios greater than 1.0 are associated with an increased risk of death; those with risk ratios less than 1.0 are associated with a decreased risk. Risk ratios are considered significant if their 95% confidence limits (95% C.L.) are either completely above or completely below 1.0.

The interval risk ratio (RR) for death was calculated for the time to the ED, the time in the ED, the total time (time to ED + time in ED), and the SBP on arrival to the ED.

Logistic regression was used to model predictions of outcome using the continuous variables of time and SBP within the time intervals that were found to have significant risk ratios.

PTSF Results - Abdominal Surgery

Two hundred fifty patients met the predetermined selection criteria. Of those two were excluded because the time to the ED seemed extraordinary: one patient was recorded as having an injury time 8 hours 1 minute prior to ED arrival with a SBP of 58 mmHg, the other patient was recorded as having an injury time 7 days 20 hours 16 minutes prior to ED arrival with a SBP of 80 mmHg. Five other patients were excluded because the recorded time in the ED exceeded 24 hours.

In the final cohort of 243 patients studied, the SBP on arrival to the ED ranged from 30-90 mmHg, with 200 patients having a SBP less than 90 mmHg. Elapsed time to the ED ranged from 7-185 minutes, with a median of 43 minutes. Time in the ED ranged from 7-915 minutes, with a median of 55 minutes; 201 patients were within the PTSF 120-minute quality

assurance (QA) standard (83% with 95% confidence limits of 77% -- 88%). Total time from ambulance dispatch or injury to arrival in the OR or departure from the ED ranged from 28 – 938 minutes, with a median of 110 minutes. Overall, 98 patients died (40% with 95% confidence limits of 34% - 46%); 4 died in the ED.

As expected, the risk of death was significantly influenced by the systolic blood pressure on arrival in the ED. Among these patients with systolic blood pressures of 90 mmHg or less, the risk of death was significantly higher in those patients whose SBP was less than 60 mmHg and significantly lower in those patients who SBP was 80 mmHg or higher.

The risk of death was not significantly influenced by the time between dispatch or injury and arrival at the ED. The risk was increased between 30 and 60 minutes, but not significantly, suggesting the possibility of an increased risk with delays in transport, followed by a self selection of survivors with long delays.

The risk of death increased with time spent in the ED, becoming significant for the interval 61-90 minutes, and then significantly decreased with stays beyond 90 minutes. The pattern suggests increased risk with delays in the ED, followed by a bias toward stable patients with further delays.

The risk of death increased with total time (time to the ED and in ED), becoming significantly higher for the interval 61-90 minutes, then decreased beyond 120 minutes, becoming significantly lower beyond 240 minutes. The results for the total time seem to follow the patterns of its components.

We made a logistic regression model of the probability of death for those patients with a significant increased risk of death with time spent in the ED, namely those whose stay was 90 minutes or less. For those patients (N=165), a logistic regression was done based on the SBP on arrival in the ED in mmHg, the pre-hospital time (PHT) in minutes, and the time in the ED (EDT) in minutes:

$$\ln(p/(1-p) = 3.36166 - SBP \times 0.05276 - PHT \times 0.00032 + EDT \times 0.01461.$$

The 95% confidence limits on the coefficient for time in the ED (0.01222 – 1.19553) confirm a significant positive correlation between time in the ED and the probability of death for patients departing the ED within 90 minutes of arrival.

The highest average impact of time spent in the ED was an average increase in the probability of death of 0.0035 (0.35%) /minute in the ED, or approximately 1/300 patients/minute. It occurred with the shortest

prehospital time (7 minutes) and a neutral SBP of 78 mmHg. The lowest average impact was an average increase in the probability of death of 0.0011 (0.11%)/minute in the ED, or approximately 1/900 patients/minute. It occurred with the longest prehospital time (185 minutes) and the lowest SBP of 30 mmHg, which was the main predictor of outcome.

- For abdominal injuries:
  - Patients with isolated vascular or solid organ injuries with shock had 136 deaths per 400. Without shock (SBP > 90 mmHg), there were 178 deaths in 1,889 patients.
  - Perforated bowel with shock, there was one death in twenty-three patients. Without shock, no deaths in 261 patients.
  - Solid organ or vascular injury producing shock carries a high likelihood of death, but abdominal injury with bowel injury even including peritonitis, does not carry a high risk of death with delays up to two days.

PTSF Results – Thoracic Surgery

42 patients were identified; 23 died (55%, 95% CL = 39 -70%); 7 died prior to thoracotomy, 2 of them having lost their blood pressure between initial assessment at the scene and arrival at the trauma center. The immediate risk of death for the 42 patients was 0.4% per minute from the recorded time of injury. Patients who died also had lower SBPs on ED admission (98 mmHg $\pm$ 9 SE vs. 135 mmHg $\pm$ 6 SE, P=0.01), were more likely to have hemothoraces (52% vs. 11%, p=0.01), and were older (50 years $\pm$ 5 SE vs. 32 years $\pm$ 3 Se, p=0.01). All 9 patients with SBPs < 90 on admission died (100%, 95% CD=66-100%). The lowest mortality rate was in the group of 19 patients < 55 years old who were not hypotensive (SBP > 90 mmHg) and did not have a hemothorax; their mortality rate was 16% (95% CL=3-40%). The mortality rate for 23 patients either > 55 years old or hypotensive (SBP < 90 mmHg) or with a hemothorax was 87% (95% CL=66-97%).

Conclusions: For patients with transected thoracic aortas who did not die immediately, the risk of death increased 0.4% (1/256 patients) for every minute prior to thoracotomy. Patients who were hypotensive on initial assessment all died. Patients with transected thoracic aortas and either hemothoraces or advanced age (> 55 years) also had an increased risk of death. Young patients without hypotension or hemothoraces had encouraging prognoses.

Summary of Findings – PTSF

- Patient arriving with systolic blood pressure < 90 mmHg, requiring surgery had an increased risk of death over the first 90 minutes of approximately 1% for each three minutes. This assumes optimum therapy.
- Solid organ or vascular injury producing shock carries a high likelihood of death, but abdominal injury with bowel injury even including peritonitis, does not carry a high risk of death with delays up to two days.
- Blunt aortic injury has an increased risk of death over time, approximately the same as those patients with shock (SBP < 90 mmHg) from other causes.
- Isolated subdurals and epidural hematomas showed no difference with time over a span of one day.
- Isolated femoral fractures showed no difference with time.

Burns

No substantial database on burn injuries that could be used to evaluate the impact of severity of burn and delay in access to treatment on outcome could be defined. The contractor had a number of conversations with burn experts around the world, including and most frequently with Colonel Basil Pruitt, US Army (Ret), previous Commander of the Burn Center and Institute of Surgical Research, Brooke Army Medical Center, Fort Sam Houston. Ultimately, Dr. Pruitt used the consensus opinion of senior burn surgeons in the United States to generate a tabulation of burn severity and outcome over time.

A similar tabulation was obtained from UK sources.

Blast Injury

No database exists to properly evaluate the effect of severity of blast injury on outcome over time. The contractor worked with a number of authorities on blast injury through the world. The primary source of information and advice on blast injury was Graham Cooper, PhD., Group Leader (Trauma), Biomedical Sciences, Dstl Porton. Doctor Cooper is widely recognized as a leading authority on blast injury. A substantial part of his professional career has been devoted to analysis of clinical and experimental data on blast injury for the United Kingdom Ministry of Defense.

Tab 1. Report on Injuries in General

- ## Anatomic Pathophysiology of Death following Injury

The pathophysiological process of early death following injury in civilian or military settings is similar and results from central nervous system injury, exsanguination, failure to ventilate or oxygenate or massive total body trauma that might occur from being crushed in a building collapse or from a nearly bomb explosion. An overall breakdown of the pathophysiological process of battlefield deaths is shown in Table 1. This can be compared with the causes of death in the civilian sector Table 2. In both cases it can be seen that hemorrhage is involved in about half of early post-injury deaths.

Table 1. Battlefield Deaths – Major Groupings by Cause	
Cause	**Percent**
Exsanguination	46
Torso (80%)	
Limb (20%)	
Brain (CNS) Injury	21
Pulmonary Injury (including Airway)	5
Airway (1%)	
Tension Pneumothorax (2%)	
Sucking Pneumothorax (2%)	
Mutilation (including Incineration)	10
Multiple Injuries	10
DOW	8
Early (4%*)	
Late (4%)	

Table 2. Civilian Deaths			
	Prehospital	**Acute In-Hospital**	**Combined**
Cause of Death			
CNS	43%	40%	41%
Exsanguination	36%	51%	45%
Exsanguination & CNS	9%	5%	6%
Other/Undetermined	12%	4%	8%
*Adapted from Sauia, et.al. J Trauma			

The timeline of civilian deaths inhospital is portrayed in Figure I from Baltimore Shock Trauma Unit.
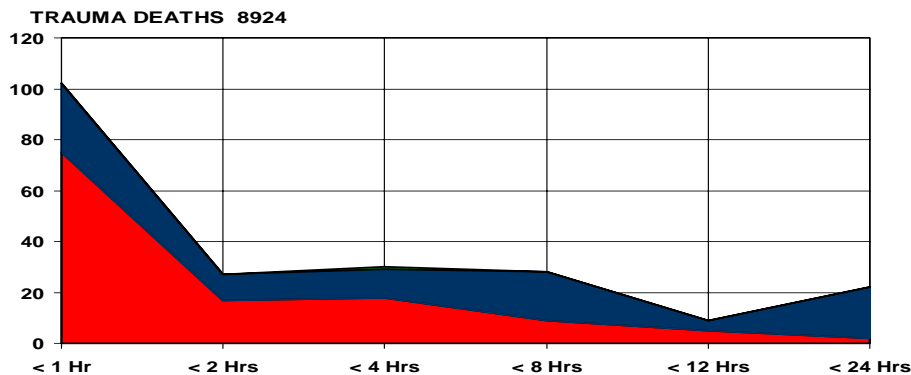
TRAUMA DEATHS 8924

Figure I.
Red – Deaths from Hemorrhage
Blue – CNS Death

The main differences between combat and civilian injury deaths are:

1. <u>The Nature and Severity of Injuries</u>. In the military setting penetrating injuries predominate, mainly due to fragment wounds, but in urban combat environments bullets prevail. Combat injuries are highly lethal with an overall mortality of about 25%.
2. <u>Time to Death</u>. Because of the massive trauma inflicted by contemporary weapons of war, death from combat injury is often very sudden, many occurring within minutes of injury.
3. <u>Place of Death</u>. Because of persistence of threat, difficulty in locating the casualty and delay in evacuation, the vast majority of deaths (about 90%) occur prior to reaching a medical care facility such as a battalion aid station or forward surgical environment. In the civilian setting, about 35-50% of injury deaths occur prior to hospitalization though direct comparison is difficult because of the civilian DOA (died on arrival) category which is not in most military statistics.

Given a clear understanding of the similarities and differences, it is possible to use data from both civilian and military to gain a deeper understanding of the immediate consequences of injury.

To the care provider, the primary sources of information about an injured are the anatomy of the injury and the physiological status of the patient.

Additional information can be obtained from the knowledge of the causative weapon. A fragment will impart less energy than a bullet from a military firearm. However an exact knowledge of the cause of the wound will often be unknown or obscure. Thus an appreciation of the anatomy and physiology of the injury will dictate immediate therapy. The prevalence and risk of death associated with injury in various body areas is given in Table 3. Injuries in some body areas are so severe and lethal that there is little added effect on mortality of injuries in other areas, e.g. head, chest. In other areas the effect of injury elsewhere is profound, e.g. abdomen, limbs.

Table 3. **Risk of Death of Penetrating Combat Injury**				
	Prevalence	Overall Mortality when Primary Injury	Overall With Other Injury	In-Hospital Mortality
Head	20%	77%	78%	26%
Face	6%	7% Est	18%	1%
Neck*	2%	20% Est	30%	5%
Chest	14-20%	66%	79%	14%
Abdomen	8-12%	24%	62%	11%
Limbs	65-80%	8%	40%	1%
*Excludes Cervical Spinal Cord				

Limb injuries are the most common site of injury, consistently resulting in 65 to 80% of combat injuries throughout the last century. Most limb injury deaths result from early exsanguination associated with devastating injuries or injuries elsewhere. The survival rate of isolated limb injuries reaching clinical care settings is over 98%. It can be concluded that low severity limb injuries have very little associated risk of death. Given that death from limb injuries is most likely to be related to exsanguination. Arrest of significant limb hemorrhage will have a profound effect on the prognosis of an injured combatant. If hemorrhage can be stopped and shock if it exists, treated to maintain cerebral perfusion, the likelihood of death becomes remote, even with significant delays in access to care.

Exsanguination from limb injuries still accounts for a significant proportion of combat injury deaths (7-10%) and probably represents the largest fraction of potential preventable deaths in a combat setting. This is in part due to the group of injuries in junctional areas such as the upper thigh and axilla where tourniquet or compressive control of hemorrhage is technically problematic, particularly in a tactical setting. These injuries are defined as "limb injuries", but are really more similar to the problems faces in torso injuries where direct control of hemorrhage is difficult or impossible.

The Principal Investigator was asked to bring a particular focus to torsal injuries.

A group of nearly 1000 (AIS 3-6) severe thoracoabdominal injured males ages 18 to 45 from MTOS was found to have a mortality of 29% for those patients with abdominal or thoracic injury alone and 49% for those patients with combination thoracoabdominal injuries.

The prognosis and time to death associated with the degree of hypotension is shown in Table 4 for this patient population.

SBP	% Die	Mins from ED Adm to Death Median
90	4.2	419.0
76-89	8.1	188.0
50-75	45.8	161.0
1-49	57.1	68.0
0	96.9	16.0
Unknown	48.0	53.5
All	23.0	24.5

Analyses of the Pennsylvania Trauma Outcome Study (PTOS) show very low mortalities in patients with abdominal injuries without shock (<0.05%).

It should be stressed that both these data sets are from civilian settings on patients treated in trauma centers and from time of admission.

Clearly severe torsal and proximal limb injuries involving the axilla or groin that cause hypotension are the most significant challenge to survival in the tactical environment. It is this group of patients where delay in access to care will have a profound effect on preventable mortality. Mortality increases with increasing hypotension and continuous blood loss. A patient who is in an uncontrolled shock state following these injuries should ideally get access to surgery within two hours.

Other body areas are discussed in detail in the subsequent sections.

- **<u>A Profile of Combat Trauma</u>**

A PROFILE OF COMBAT INJURY

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ABSTRACT

Traumatic combat injuries differ from those encountered in the civilian setting in terms of epidemiology, mechanism of wounding, pathophysiological trajectory following injury, and outcome. Except for a few notable exceptions, data sources for combat injuries have historically been inadequate.

Although the pathophysiologic process of dying is the same, i.e., dominated by exsanguination and central nervous system injury, in both the civilian and military arenas, combat trauma has unique considerations with regard to acute resuscitation, including (1) the high energy and high lethality of wounding agents; (2) multiple etiology of wounding; (3) preponderance of penetrating injury; (3) persistence of threat in tactical settings; (4) austere, resource-constrained environment; and (5) delayed access to definitive care. Recognition of these differences can help bring focus to resuscitation research for combat settings and can serve to foster greater civilian-military collaboration in both basic and transitional research.

KEY WORDS

INTRODUCTION TO COMBAT TRAUMA

For the past 35 years, that is, since the Vietnam War, advances in trauma care have largely occurred in the civilian setting, with improved treatments and systems of care resulting in better outcomes. Whether such improvements are applicable to injuries sustained in combat is the source of ongoing discussion.

The characteristics of combat injuries differ from those of injuries encountered in civilian practice in terms of epidemiology, mechanism of wounding, pathophysiological trajectory following injury, and outcome. Further, the nature of combat injuries is likely to change due to changes in the ways wars will be fought; such changes may influence therapeutic tactics and techniques, and military medical planning and logistics.

The distribution of the mechanisms of combat injuries is strongly dependent on the branch of military service and how the combat is fought (Table 1).[1-4] For instance, 90% of combat injuries occurring in infantry combat have been due to penetrating missiles, a proportion very different than that observed in naval and air combat and, indeed, in civilian trauma, in which blunt trauma predominates.

The incidence of thermal injuries is particularly high in certain military environments. For example, on board ship and among the crews of armored fighting vehicles, a figure as high as 47% was quoted for American tank crews during WWII, but this varied from the most minor to the most major burn. Of note, in these settings burns are frequently just one element of multiple-etiology injuries to a combatant which might include both blast and penetrating injury.

Today, primary blast injury is relatively uncommon, but there is great concern that the development of modern explosive devices including thermobaric weapons and fuel-air explosives may make blast injury a more important component in the etiology of combat injuries in the future. At present, the majority of combat injuries are penetrating, and most are due to fragments from explosive munitions such as shells or grenades (70-80%) rather than bullets fired by military small arms.[5]

OTHER CONTRIBUTORS TO FORCE NON-EFFECTIVENESS

Although combat injuries are the most visible and arresting toll of war on the human body, from a medical planning standpoint, such injuries are only one aspect of military medical care in combat. Disease and non-battle injury can also reduce fighting force strength. Losses due to combat injuries actually constitute a minority of the total attrition in the theater of operation. Only about 20% of the U.S. Army non-effective rates in World War II, Korea, and Vietnam were due to combat injuries, whereas disease accounted for more than two-thirds of the attrition (Table 2).[6] Combat injuries, however, have a disproportionably greater effect on the fighting power of the command because, for the most part, they occur in the combat branches, i.e., infantry, armor, etc.

The actual number of combat injuries incurred by a given sized military unit is a highly variable quantity dependent on many factors, of which the intensity of the fighting is only one. Historical data indicate that rates of combat injury are inversely proportional to the size of the unit for a given level of fighting.[7] The reason for the greater attrition in smaller units is that they contain a higher percentage of combat arms personnel. Thus, in typical late 20th century combat, an entire division (often comprising thousands of personnel) might be expected to lose only 1% of its

strength per day, whereas its constituent brigades, battalions, and companies (often comprising less than a few hundred personnel) may lose 3%, 10% and 25%, respectively. Combat operations likely to be the norm in the future will be characterized by the deployment of a limited number of small combat units, thus resulting in fewer overall casualties but substantial losses among the units actually engaged.

COMBAT INJURY DATA

Data sources for combat injury statistics are multiple and often crude, with absolute numbers of killed and wounded being variably represented as census data or sample data, but usually as a normalized or indexed statistic (e.g., 20% killed) or rate (e.g., 10 killed per 1000 at risk). Indexed statistics compiled from data from hospitals or surgical treatment facilities in which the denominator consists only of those reaching such sites are notorious for underestimating the magnitude and nature of the problem. Early lethality and delay in evacuation, the hallmarks of combat trauma, plus delayed access to definitive care, create a self-selected population. Combat mortality in hospitals under conventional battle situations has been reported as 4% or less since World War II, sometimes approaching 2% in certain circumstances (such as the Falklands) although overall mortality is 5 to 10 times greater.[1]

WDMET Database

Several of the more useful studies on epidemiology and outcome of injury have been performed on the Wound Data and Munitions Effectiveness Team (WDMET) database.[8] This is a database of 7,989 patients comprising meticulously collected data from 1967 through 1969 in Vietnam. Its great importance lies in that it covers the entire spectrum of combat injury from those with minor injuries to those who sustained major injuries or were killed. Because it represents a

sample of Marine and Army personnel in jungle combat, it does not represent the full spectrum of combat injuries such as tank and artillery heavy combat, aerial combat, and naval warfare. It does, however, provide a lasting standard against which all future epidemiological studies of combat injuries must be judged. Some summary analyses of this database are given below.

- *Mechanisms of Wounding*

The mechanisms of wounding in the WDMET database are given in Figure 1.[1] Such figures are typical of modern combat, though recent data on urban combat offer some interesting shifts between fragment and bullet injuries (*vida infra*). Of note, most fragment injures are multiple in nature.

- *Site of Primary Injury*

In treated casualties, by far the most frequent injuries are soft tissue injuries involving skin, fat, and skeletal muscle especially of the limb, and fractures of long bones (Figure 2).[1] There is remarkable consistency throughout the past century (Table 3).

- *Site of Fatal Injury*

The sites of fatal injury (Figure 3)[1] are quite different from the patterns seen in casualty populations that include a predominance of surviving wounded (Figure 2, Table 3). The latter consist primarily of casualties with soft tissue and orthopedic injuries whereas wounds of the head and torso predominate in the dead. Penetrating wounds of the head and chest have a fearsome lethality, being 78% and 72%, respectively.[1]

Death following penetrating combat injury is most commonly related to central nervous system injury or exsanguinating hemorrhage. Approximately 50% of those who die do so as a result of exsanguinating hemorrhage. Although approximately 80% of exsanguinating hemorrhage deaths are in the torso, where control of hemorrhage is difficult if not impossible in the tactical environment, approximately 20% of such deaths are in areas where the hemorrhage is from vessels that might be controlled by pressure, i.e., in the neck, large soft tissue areas, and especially the limbs.[9] Increasing emphasis on the wearing of effective torso protection is likely to reduce the number of casualties who in the past would have died of wounds to the chest and abdomen.

In recent conflicts, hemorrhage from limbs continues to account for about a tenth of deaths (note that this is of all deaths, not just of those dying of hemorrhage; see Table 3.)

The WDMET database suggests that exsanguination from extremity wounds accounts for more than half of the potentially preventable deaths in combat,[1,9] thus the continued emphasis on hemostasis as the primary maneuver in combat casualty care and the research emphasis on agents which might provide a means of decreasing inaccessible or uncontrollable hemorrhage. Other potentially preventable deaths include simple airway obstruction and other sources of hemorrhage that are surgically remediable if such care can be provided in a timely fashion (Figure 4).[1,10]

MORTALITY STATISTICS

The most common ways of representing mortality statistics from combat injury are to describe

the data in terms of "killed in action" (KIA) and "died of wounds" (DOW). KIA is the

percentage of the casualty population dying prior to reaching medical care at the battalion aid

station or equivalent. The KIA rates of conflicts over the past 150 years have remained about

20%, (Figure 5) thus testifying to the lethality of combat weapons and the constancy of human

anatomy and physiology.[1] This lethality of weapon systems is well-known and varies from 1 in 3

for a military bullet, through 1 in 5-7 for a shell, to 1 in 20 for a preformed fragmentation device

(grenade).

The denominator for a DOW statistic should be limited to those personnel who have been

admitted to a medical treatment facility. It should not include those with minor injuries who are

returned to duty or are not hospitalized. Historical data for those in the DOW category are

shown in Figure 6.[1]

By the end of World War II, the lessons learned in the previous 30 years rapidly converged with

modern anesthetic, blood transfusion, and antibiotics, and a doctrine that emphasized rapid

evacuation to a surgical treatment facility for the critically wounded reduced the DOW rate to

half of what it was for the US Army in early World War II.

THE CHANGING NATURE OF COMBAT

Since the end of the Cold War, the concepts of modern battle have changed considerably.

Although the specter of mass armies facing each other can never be ruled out, modern combat is

more often described as asymmetric low density, very remote, or disbursed (e.g., Afghanistan), or non-linear and urban (e.g., Mogadishu).

Although there is debate about the importance of urban conflict relative to other environments in increasing lethality, it certainly adds multiple dimensions of complexity. General Charles Krulac, former Commandant of the U.S. Marine Corps who served two tours of duty in Vietnam, described the urban combat environment as a "three-block war" where "…we expect to be providing humanitarian assistance in one part of the city, conducting a peacekeeping operation in another and be fighting a lethal, medium intensity battle in yet a third part of the city." [11] Asymmetric warfare refers to the discordance between the opposing forces in terms of tactics and weapons. This might refer to an urban guerilla war, where Special Forces or Marines attempt to encounter an enemy that cannot be distinguished from civilians in an urban population. To many, the epitome of asymmetric conflict is a suicide / homicide bomber in a crowd of unsuspecting civilians.

In low-intensity urban conflict, it is difficult to identify a casualty and get immediate qualified care. Thus, there is increasing reliance on self and buddy aid for point-of-wounding care. Dispersed, low-density conflict also creates problems with access to and egress from the tactical environment. When a combat medic or equivalent can get to the casualty, interventions must be focused and effective. Even without medical gear, combatants typically carry or wear as much as 45 kg (100 lb) of equipment into combat. Thus, it becomes important that medical supplies are as compact and lightweight as possible. This consideration may well affect the clinical protocol; e.g., a propensity for low-volume resuscitation may be influenced by the fact that 1000cc of isotonic crystalloid weighs 1 kg (2.2 lb).

Modern urban combat continues to be highly lethal. Recent data from the Surgeon General of Israel regarding Israeli Defense Force (IDF) operations in West Bank Palestinian refugee camps show 24% mortality of those injured severely enough to warrant hospitalization (personal communication to HR Champion from the Surgeon General of the IDF, 2002). In this setting, the most common cause of injury was from a bullet. Chest injuries accounted for 67% of moderate, severe, and lethal injuries. Almost three fourths (73%) of those with chest injuries died.

Compared with previous IDF urban combat in Lebanon, the recent IDF data (above) show an increase in the number of bullet wounds from 13% to 48% and a decrease in the number of shrapnel wounds from 74% to 17% of all injury types. Chest and abdominal wounds increased from 19% to 27% of moderate and severe injuries, and exsanguination as the cause or a contributory cause of death increased from 41% to 56%. Evacuation times for the IDF to medical facilities compare extremely favorably with urban American Level I trauma centers: an average of 53 minutes. Although these outcomes cannot translate into other tactical settings, the IDF experience does serve to emphasize the importance of hemorrhage control in early management of combat casualties.

TIME AND COMBAT CASUALTY CARE OF HEMORRHAGE

Throughout history, an imperative of those providing combat casualty care has been to bring treatment as quickly as possible to the casualty. The Wurtz, a long, sausage-shaped cart which was deployed by Baron Percy (a contemporary of Larrey) to bring surgical instruments and dressings for 1200 casualties on to Napoleonic battlefields, was one such initiative. In our own day, this imperative has resulted in the helicopter evacuation that characterized the latter stages of the Korean War and all of the Vietnam War.

One of the most interesting and successful clinical investigations ever carried out on combat casualties applicable to hemorrhage as a cause of death was that of the Board for the Study of the Severely Wounded during the last six months of WW II in Italy.[12] Extensive hemodynamic and biochemical measurement were made in several hundred seriously wounded combat casualties at an average time of about 6.5 hours after injury. Shock was graded into four categories using an elaborate clinical grading system. Blood pressure and heart rate were measured at the time blood volume was determined using a dye dilution methodology. The results are shown in Table 4.

Not surprisingly, casualties with the greatest blood loss were most likely to die and a blood volume reduced to 50% of normal was likely to be fatal. More recent studies show similar results.[13] A study on penetrating torso injuries from the Pennsylvania Trauma Registry (patients aged 18-45) reveals the increase in risk and reduction in time to death with increasing hypotension (Table 5).[13]

Anatomical considerations indicate that about perhaps one tenth of all deaths are due to hemorrhage from extremity wounds and therefore may be preventable by battlefield first aid. However, the tactical situation (i.e., enemy action) probably precludes effective first aid in one-half of such casualties. Similarly, anatomical considerations suggest that perhaps 10% of those who die of exsanguinating truncal hemorrhage have potentially surgically correctable wounds (i.e., iliac artery transaction) (Personal communication to COL Richard Satava, MC USA, DARPA, 1997, based on 100 casualty killed in action who died 10 minutes or more after wounding). Because death occurs before such casualties can be evacuated to a surgical facility, salvaging such casualties will require a radically new approach to managing the otherwise fatally wounded.

Data from the Vietnam War show the importance of improved treatment of exsanguinating hemorrhage/shock, given that (1) about 10% of casualties admitted to a medical treatment facility were observed to be in shock,[14] (2) slightly less than 1% of admitted casualties had shock as the primary cause of death,[10] and (3) 50% of those who were killed succumbed to hemorrhage.

Assuming 1000 casualties, a KIA rate of 20% (200 dead) and a DOW rate of 3.4% (27 died), one calculates that about 109 deaths are due to exsanguinating hemorrhage/shock.[10] Because the total at risk of dying of these causes is about 180 casualties, exsanguinating hemorrhage/shock has a lethality of slightly less than two-thirds. Clearly, more effective treatment modalities are indicated, especially for those who die before admission to a medical treatment facility.

Death from hemorrhage occurs over a period of time related to the rate of blood loss. In both Somalia and Afghanistan, U.S. military personnel have bled to death in the combat zone over a period of hours, although the usual time is 5-10 minutes. Thus, the window of opportunity continues to be somewhat limited for individuals with uncontrolled hemorrhage whose systolic blood pressure (SBP) falls below 90 mmHg. Paradoxically, the battlefield offers a larger target population because of the delay in evacuation compared with those in civilian settings. Those with ongoing hemorrhage of a rate that does not result in prompt exsanguination might benefit from resuscitation strategies, tactics and techniques that aim to stretch the mythical "golden hour" to the 4- to 6-hour window before definitive care can be exercised.

Although the relationships among blood pressure, degree of shock, and volume lost are by no means certain, it is generally accepted that approximately 25% blood loss will cause a patient to go into shock with a SBP < 85–90 mmHg and that blood loss of greater than approximately 60%

33

will present an irretrievable state with SBP < 50 mmHg, at which point cerebral perfusion and consciousness begin to dissipate. Individuals presenting with a SBP < 90 mmHg will have diminished chance of survival over time, which will be also be largely dependent on rate of bleeding and thus, hemostasis and ability to maintain vital organ perfusion pressure are critical. If the combatant starts with a circulating blood volume of 5000 cc and a loss of 3000 cc is lethal, with 1000 cc producing shock, then an average blood loss of < 20 cc/minute will cause an individual to exsanguinate to the point of death over a period of 2 hours. The judicious use of a volume expander that would provide 1000 cc of expansion over a period of 1 hour might well protract the window of opportunity for an hour or more with each dose.

It is on the basis of such calculations that the recommendation was made for volume expansion with low-volume, low-dose (250 cc) hypertonic saline dextran or colloid, given over a period of 15 minutes. This anticipates that volume expansion would likely amount to some 750 – 850 cc over a period of 30 minutes.

The importance of balancing infusion volumes and rates in patients with certain estimated volumes of blood loss is of less consequence in a civilian setting where prompt access to definitive surgery is possible. However, these issues have increasing importance in tactical settings where the need to titrate care in a simple and reliable fashion over a period of hours might be critical in allowing a casualty to survive long enough to reach definitive care.

SUMMARY AND CONCLUSIONS

There are substantial differences between acute resuscitation of injured patients in the civilian and military arenas. These are the result of factors unique to combat, including (1) the high

energy and high lethality of wounding agents, (2) multiple etiology of wounding, (3)

preponderance of penetrating injury, (3) persistence of threat in tactical settings, (4) austere

resource-constrained environment, and (5) delayed access to definitive care.

The physiological consequences of these differences include the following:

- Higher mortality for shock (65%) compared to that in a civilian setting (50%)

- Higher mortality prior to physician-directed emergency care, such as that provided in a

  casualty clearing station, battalion aid station, or where forward surgical capability might be

  present. Death occurring prior to the provision of effective combat casualty care still accounts

  for over 90% of combat deaths

- Patients with slower rates of hemorrhage will reach shock states and present sicker than they

  would normally present in a civilian setting, thus affording a target of opportunity for

  improved resuscitative care

- Improved resuscitative care, i.e., carefully titrating volume expansion with blood loss, can

  offer substantial improvements in care for combat casualties.

Combat settings are not an environment for resuscitation research. Civilian trauma centers offer

an environment for research that may benefit both the combat casualty and the civilian trauma

patient. In both settings, the pathophysiologic process of dying is the same, i.e., dominated by

exsanguination and central nervous system injury. Although the temporal trajectory of these

processes may differ, recognition of these differences can serve to foster greater civilian-military

collaboration in both basic and transitional research.

FIGURES

Figure 1. Mechanism of Wounding [1]

Figure 2. Site of Primary Injury [1]

Figure 3. Site of Fatal Primary Injury [1]

Figure 4. Mechanism of death in ground combat, Vietnam War [1,10]

KIA, killed in action; DOW, dead of wounds

Figure 5. Combat casualties: Percent killed in action, 1854-1989 [1]

Crimean War, 1854-55 (British battle casualties); American Civil War, 1861-65

(Union); Franco-Prussian War, 1870-71 (German); Russo-Japanese War, 1904-05

(Japanese); France & Flanders, 1914-18 (British); Conquest of France, 1940

(German); Russian Front, 1942 (German); Italy, 1944-45 (American); Korean War,

1950-53 (American); Vietnam War, 1964-73 (US Marine Corps); Northern Ireland,

1970-84 (British); Afghanistan War, 1979-89 (Russian)

Figure 6. Combat casualties: Percent died of wounds after taken to treatment facility,

1854-1989 [1]

Crimean War, 1854-55 (British battle casualties); American Civil War, 1861-65

(Union); Franco-Prussian War, 1870-71 (German); Russo-Japanese War, 1904-05

(Japanese); France & Flanders, 1914-18 (British); Conquest of France, 1940

(German); Russian Front, 1942 (German); Italy, 1944-45 (American); Korean War,

1950-53 (American); Vietnam War, 1964-73 (US Marine Corps); Northern Ireland,

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- **Rules of Thumb for Mission Commanders**

  - Casualties who have an altered state of consciousness or impaired judgment from either pain or pain medications should be disarmed immediately.

  - Casualties with a normal state of consciousness who have either minor or controlled hemorrhage can continue as combatants.

  - The highest urgency for immediate CASEVAC is a casualty who has penetrating injury to the chest or abdomen and is conscious but has a decreased radial pulse.

  - Casualties with blunt maxillofacial trauma and either difficulty breathing or unconsciousness will have a significantly improved survival if CASSEVAC is accomplished within 1 – 2 hours.

  - Casualties with penetrating chest trauma who have increasingly severe difficulty breathing that is not relived by needle decompression will have a significantly improved survival if CASEVAC is accomplished within 1 – 2 hours.

  - The timing of CASEVAC will have little impact on survival for an unconscious casualty with either penetrating or closed head trauma (expected high mortality).

  - The timing of CASEVAC will have little impact on survival for a casualty with a tension pneumothorax whose difficulty breathing has been relieved by needle decompression (expected low mortality).

  - The timing of CASEVAC will have little impact on survival for a casualty with an extremity injury with or without shock if the bleeding has been controlled and the casualty is conscious (expected low mortality).

  - The timing of CASEVAC will have little impact on survival for an unconscious casualty with penetrating trauma to the chest or abdomen and no head injury (expected high mortality).

  - The above rules assume:
    1. Treatment per Tactical Combat Casualty Care (TCCC) guidelines.
    2. Decision about CASEVAC is made approximately 15 minutes after wounding.

Tab 2.   Report on Injuries by Body Area – MTOS Analyses & Findings

- **Abdomen**

- **Chest**

- **Massive Torso Trauma**

- **Head**

- **Limbs**

- **Neck**

- **Maxillofacial**

- **Burns**

- **Blast**

Tab 3.   Power Point Presentation

Tab 4.   Report of Combat Trauma Registry

- **Combat Trauma Registry Database**

- **Combat Trauma Registry Data Dictionary**

- **IECC Data Elements**

Tab 5.   Patient Condition Codes

Tab 6. Bibliography

Tab 7. Apendices

- **Attachment I to Task Statement 4-99B**

- **Members of Review Panel**

- **Goals & Process Review Panel**

<u>Tab 8. CD ROM</u>

- **Text**

- **Power Point Presentation**